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Research Article

Intraoperative angiography with indocyanine green to assess anastomosis perfusion in patients undergoing laparoscopic colorectal resection

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Abstract

Background: Intraoperative Indocyanine Green (ICG) angiography can be used to find a good perfusion segment before the colon cut. The most lethal post-operative complication in colorectal surgery, anastomotic leaking, frequently has disastrous clinical outcomes for the patient and has a significant financial impact on the healthcare provider. We create a real-time angiography based on the capacity of ICG to fluoresce when stimulated by near-infrared light when given intravenously. This allows us to assess the perfusion of the bowel both before and after the anastomosis. **Aim of the work:** The aim of this study is to assess the perfusion of the bowel using indocyanine green dye before and after the anastomosis in patients doing colorectal surgeries. **Patients and methods:** Prospective clinical trial from December 1, 2021 to June 1, 2023. This study was conducted on 40 patients admitted to the laparoscopic unit at Minia University Hospital. Patients are classified into two groups: the negative leak group (30 patients) and the positive leak group (10 patients). **Result:** There is a prominent difference between the two groups related to smocking and the anastomosis level. Smoking >40 packs per year is higher in the positive leak group. And the anastomosis level<5cm from the anal verge is higher in the positive leak group. and no significant difference between the two groups regarding the other data. **Conclusion** ICG-enhanced fluorescence imaging is a secure and useful method for improving visibility during laparoscopic surgery. ICG dye can be used intraoperatively to assess the anastomotic perfusion and decrease postoperative anastomotic leakage.

Key words: ICG dye, anastomotic leakage, cancer colon

Introduction

The utilization of high-definition (HD) and 3-dimensional (3-D) systems has been shown to be able to increase safety for patients and surgeon efficiency. Two major advancements in minimum surgery video imaging have been made in recent years. Laparoscopic surgery recently used indocyanine green-enhanced fluorescence to enhance visibility and offer precise anatomical information.[1] The second most frequent cancer in women and the third most common cancer overall in males is colorectal cancer.[2] ICG dye is a tricarbocyanine molecule that is anionic, water-soluble, sterile, and somewhat hydrophobic. It was created by the Kodak research laboratories in 1955 for near-infrared photography and received FDA therapeutic use. approval in 1959. Before hepatic resection in cirrhotic livers, it was employed in medicine to assess the functional reserve of the liver, analyze the architecture of the retinal arteries, and assess cardiac output. When ICG solution is administered intravenously, the catheter

binds plasma proteins, particularly lipoproteins, with little leakage into the interstitium.

The metabolites are unknown. ICG is promptly extracted and almost solely eliminated by the liver, and depending on the liver, it appears unconjugated in the bile around 8 minutes after injection.[3]The most terrifying postoperative complication after colorectal surgery is anastomotic leakage, which frequently has devastating clinical outcomes for the patient and significant financial consequences for the healthcare provider.[4] Anastomotic leakage may be caused by a number of variables, including surgical methods, patient risk factors, suture materials, or equipment, although the whole etiology is yet unknown. The most crucial element in determining anastomotic viability appears to be poor local tissue oxygenation as a result of insufficient anastomotic vascular perfusion. An intraoperative visual evaluation by the surgeon based on clinical signs such as color, bleeding edges of resection margins, pulsation, and warmth is now a frequent procedure utilized to assess anastomotic perfusion. Nevertheless, several investigations revealed that the operating surgeon's clinical judgment may have overestimated the likelihood of anastomotic leakage after colorectal surgery.[5,6]. We create a real-time angiography based on the capacity of ICG to fluoresce when stimulated by near-infrared light when given intravenously. This allows us to assess the bowel perfusion both before and after colorectal anastomosis.[6] Some anatomical regions, like the splenic or hepatic flexure, have unclear vascular architecture because they are situated on the border of numerous circulatory districts. The ICG real-time angiography permits the detection of the tumor site's vascularization in order to carry out an oncologically precise excision.[7] It might be challenging to identify the ureter when the tumor is strongly linked to the Toldt-Gerota plane. When this occurs when administering ICG solution via the catheter, the fluorescence enables ureter identification to minimize harm during the dissection.[8]

Indications of laparoscopic colorectal resection[9]: Colon cancer, large colon polyps, not amenable to endoscopic removal, Diverticulitis, Stricture (Crohn, anastomotic, radiation,etc.), Volvulus, Ischemia.

Contraindications of laparoscopic colorectal resection [10]:

hemodynamic instability, cardiopulmonary disease severe enough to warrant peritoneal insufflation, Trendelenburg posture**,** Severe adhesion due to previous surgeries**,** A tumor spreading into other organs isn't a certain contraindication

Patients and methods

Prospective clinical trial from December 1, 2021 to June 1, 2023 This study was conducted on 40 patients admitted to the laparoscopic unit at Minia University Hospital. Patients are divided into two groups: the negative leak group (30 patients) and the positive leak group (10 patients). **Inclusion criteria:** Ages > 15 and < 80 years old Patients undergoing colorectal anastomosis**. Exclusion criteria:** ICG allergy, pregnancy, Irresectable mass. LT colon cancer with distant metastasis Unfit patient with co-morbid diseases like cardiac patients. **Preoperative evaluation and patient preparation:** medical history (DM, HTN, etc.), surgical history of any previous operation**,** Symptom severity and frequency**,** parental broad-spectrum prophylactic antibiotics, and preoperative LMWH for all patients 12 h before the operation as a single dose of 40 mg subcutaneously given as a prophylaxis for DVT and PE, preparation of blood for possibility of blood loss, and blood transfusion intraoperative **colonic preparation:** patient will be on fluids 3 days before operation mechanical preparation: enemas, laxatives Chemical preparation: systemic neomycin

Laboratory Investigation: complete blood count (CBC); Coagulation Profile: Prothrombin Concentration PC, INR, PTT, PTT liver function tests, and enzymes SGOT, SGPT, ALBUMIN Renal function tests urea, creatinine,creatinine and renal function tests Serum electrolytes (K, Na, and Ca and tumor markers CA19-9 and

CEA **Radiological Investigations:** 1. Abdominal ultrasound and x-ray 2-CT abdomen with oral and IV contrast 3: Colonoscopy and biopsy 4. Chest x-ray, CT chest, and metastatic workup

Intraoperative:

1- Dissection and vascular ligation:

For a preliminary evaluation, the peritoneal cavity is probed. The sacral promontory is located, an incision is made over the medial portion of the mesosigmoid, and the sigmoid is then grabbed and retracted laterally through the left lumbar midclavicular port. The A vascular plane is attained. To protect the ureter, gonadals, and inferior mesenteric arteries, the plane in front of them is meticulously dissected. The ureter is protected. Dissect and bound inferior mesenteric vessels. Dissection in this plane is continued upwards towards the splenic flexure.

Gerota's fascia is visualized and kept undisturbed. The sigmoid colon is now being medially softly retracted. Along the Toldt white line, there is an incised lateral colonic peritoneal connection. Upward dissection is done over the lateral peritoneum. The gastrocolic omentum is split between the stomach and the transverse colon, and the renocolic and splenocolic attachments are loosened. To relieve the splenic flexure enough below, the pancreaticocolic ligament is dissected. Between the layers of the pelvic fascia, an avascular plane is used for rectal dissection. A harmonic scalpel is used to separate the mesorectum up to the resection line. Endostapler can be used to transect the colon.

2-Anastomosis

The specimen was retrieved from a pfannenstiel incision in the lower abdomen following colonic transection. After utilizing a stapler to resect the tissue, the anvil is attached to a non-absorbable purse string suture at the proximal end, and both ends are then inserted into the peritoneal cavity. The EEA stapler is carefully positioned per anally towards the peritoneal cavity. Its pointed tip is designed to perforate out of the stapler line; it is attached to the anvil already in the peritoneal cavity as well as the bowel's proximal cut end using purse string and locked. The anastomosis is finished by firing the stapler. The gadget is taken out, and a doughnut is shown.

3-Evaluation of the anastomosis by ICG dye: After the anastomosis was done, we injected 5 ml of the ICG dye intravenously. and after 2 minutes, we switch to the ICG mode on the camera to assess the perfusion of the anastomosis.

Statistical Analysis

SPSS 22.0 for Windows (SPSS Inc., Chicago, IL, USA) was used to collect, tabulate, and statistically analyze all data To evaluate if the data was regularly distributed, the Shapiro Walk test was performed The qualitative data were presented in the form of frequencies and relative percentages The Chi square test (2) and Fisher exact were used to calculate the difference between qualitative variables as specified. For parametric data, quantitative data were given as mean SD (standard deviation), whereas non-parametric data were provided as median and range..

For parametric and non-parametric variables, the independent T test and the Mann Whitney test were employed to measure the difference between quantitative variables in two groups.

All statistical comparisons were significant and two-tailed. P-values of 0.05 denote a significant difference, p 0.001 a highly significant difference, and P> 0.05 a non-significant difference.

Results

The selected patients are classified into 2 groups:

Negative leak group (30 patients)

Positive leak group (10 patients)

As regarding table (1) there was a significant decrease in the frequency of patients with BMI >25 in patients with positive leak compared with patients with a negative leak, also there was a significant increase in the frequency of patients who smoke > 40 per year in patients with positive leak compared with patients with a

negative leak, otherwise, there was insignificant variation between the two groups regarding other variables.

As regards table (2) there was an insignificant difference in albumin and cholesterol between the two groups
.
As regards table (3) there was a significant decrease in the anastomosis level in patients with a positive leak compared with patients with a negative leak, while there was a significant increase in the frequency of patients with anastomosis level < 5 cm in patients with positive leak compared with patients with a negative leak, also there was a significant decrease in the frequency of splenic flexure mobilization in patients with positive leak compared with patients with a negative leak, otherwise, there was insignificant variation between the two groups regarding the other variables.

Table 1: Demographic data between cases with -Ve leak and cases with +Ve leak

		-Ve leak	+Ve leak	P value
		N=30	N=10	
Age (years)	**Range** **Mean ± SD**	(25-72) 46.77±12.93	(20-64) 46.20±13.07	0.905
Sex	**Male** **Female**	16(53.3%) 14(46.7%)	5(50%) 5(50%)	0.855
BMI	**Range** **Mean ± SD**	(22.2-26.5) 24.35±1.28	(22.6-24.1) 23.52±0.49	0.053
BMI (≥25 kg/m2)	**No** **Yes**	19(63.3%) 11(36.7%)	10(100%) 0(0%)	**0.025***
ASA score	**I** **II** **III**	7(23.3%) 20(66.7%) 3(10%)	3(30%) 7(70%) 0(0%)	0.564
Hypertension	**No** **Yes**	17(56.7%) 13(43.3%)	7(70%) 3(30%)	0.456
DM	**No** **Yes**	24(80%) 6(20%)	5(50%) 5(50%)	0.066
Smoking >40 pack-year	**No** **Yes**	22(73.3%) 8(26.7%)	3(30%) 7(70%)	**0.014***

As regards table (4) there was a significant decrease in F MAX and Slop in patients with a positive leak compared with patients with a negative leak, while there was a significant increase in T max, T ½ max, and TR in patients with positive leak compared with patients with a negative leak, while, there was insignificant difference between the two groups regarding F MIN.

Table 2: laboratory data between cases with -Ve leak and cases with +Ve leak

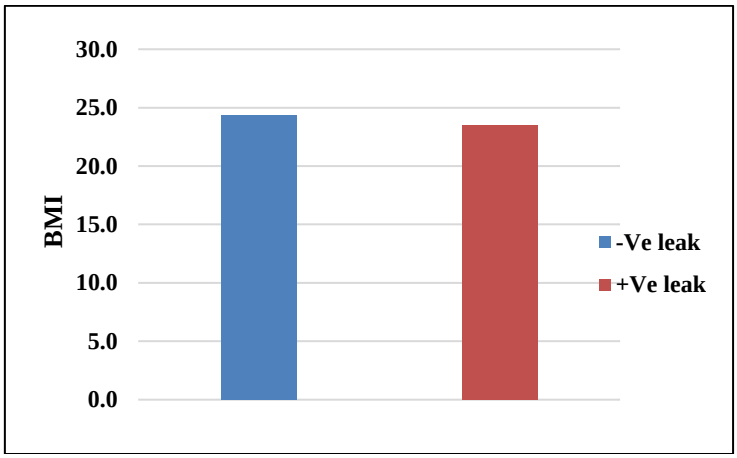
		-Ve leak	+Ve leak	P value
		N=30	N=10	
Serum albumin (g/I)	**Range** **Mean ± SD**	(3.1-4.9) 4.22±0.43	(3.8-4.9) 4.28±0.34	0.709
Albumin (<4 g/dL)	**No** **Yes**	24(80%) 6(20%)	8(80%) 2(20%)	1
Cholesterol (mg/dl)	**Range** **Mean ± SD**	(162-226) 192.93±19.91	(190-222) 205.2±11.69	0.074
Cholesterol (≥220 mg/dl)	**No** **Yes**	27(90%) 3(10%)	8(80%) 2(20%)	0.408

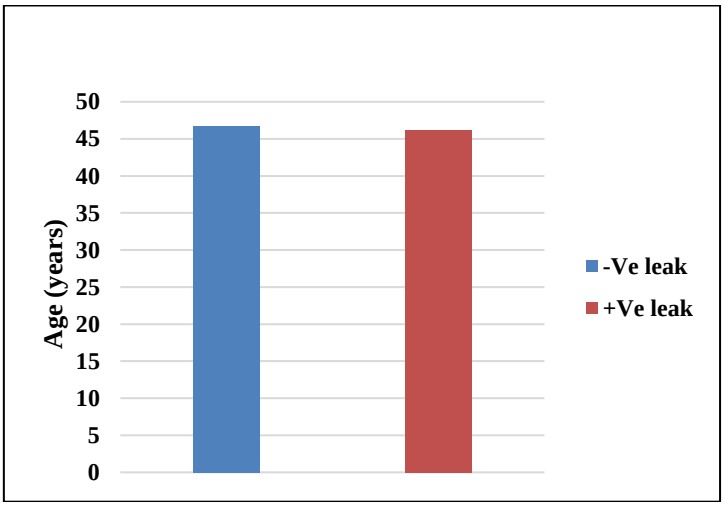
Table 3: Operative data between cases with -Ve leak and cases with +Ve leak

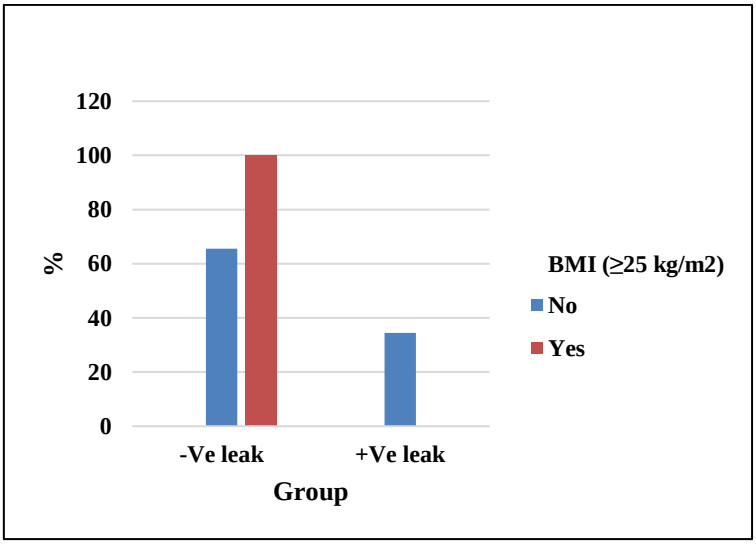
		-Ve leak	+Ve leak	P value
		N=30	N=10	
Preoperative chemoradiation	**No**	29(96.7%)	8(80%)	0.083
	Yes	1(3.3%)	2(20%)	
Cancer obstruction	**No**	23(76.7%)	5(50%)	0.111
	Yes	7(23.3%)	5(50%)	
Low anterior resection	**No**	12(40%)	1(10%)	0.079
	Yes	18(60%)	9(90%)	
Anastomosis level (cm)	**Range**	(3-8)	(2-6)	**0.004***
	Mean ± SD	5.33±1.42	3.8±1.14	
Anastomosis level <5 cm)	**No**	21(70%)	2(20%)	**0.006***
	Yes	9(30%)	8(80%)	
Splenic flexure mobilization	**No**	7(23.3%)	7(70%)	**0.007***
	Yes	23(76.7%)	3(30%)	
Ileostomy	**No**	19(63.3%)	5(50%)	0.456
	Yes	11(36.7%)	5(50%)	
Inferior mesenteric artery high ligation	**No**	8(26.7%)	1(10%)	0.274
	Yes	22(73.3%)	9(90%)	
Transection line change	**No**	28(93.3%)	8(80%)	0.224
	Yes	2(6.7%)	2(20%)	

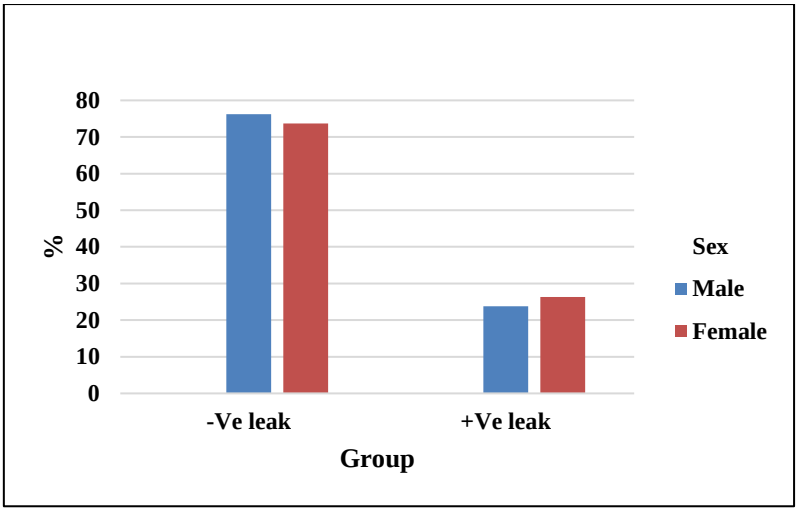
Table 4: Duplex data between cases with -Ve leak and cases with +Ve leak

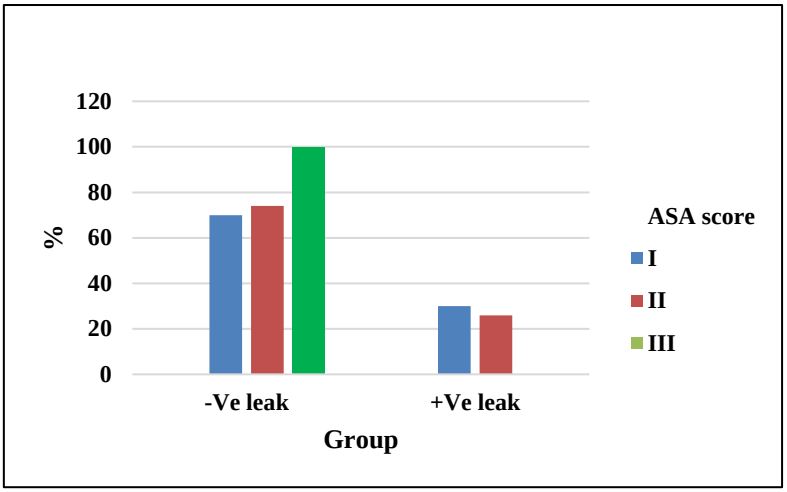
		-Ve leak	+Ve leak	P value
		N=30	N=10	
F MIN (AU)	**Range**	(8-12)	(7-17)	0.143
	Mean ± SD	10.43±1.1	11.3±2.58	
F MAX (AU)	**Range**	(51-63)	(22-48)	**<0.001***
	Mean ± SD	57.53±3.27	34.2±7.52	
Slope (AU/sec)	**Range**	(1.92-2.78)	(0.4-0.96)	**<0.001***
	Mean ± SD	2.46±0.2	0.69±0.2	
T MAX (sec)	**Range**	(24-34)	(41-78)	**<0.001***
	Mean ± SD	30±2.29	62.7±12.04	
T 1/2MAX (sec)	**Range**	(10-13)	(26-56)	**<0.001***
	Mean ± SD	11.53±0.73	40.1±7.82	
TR	**Range**	(0.33-0.46)	(0.5-0.64)	**<0.001***
	Mean ± SD	0.39±0.03	0.59±0.04	

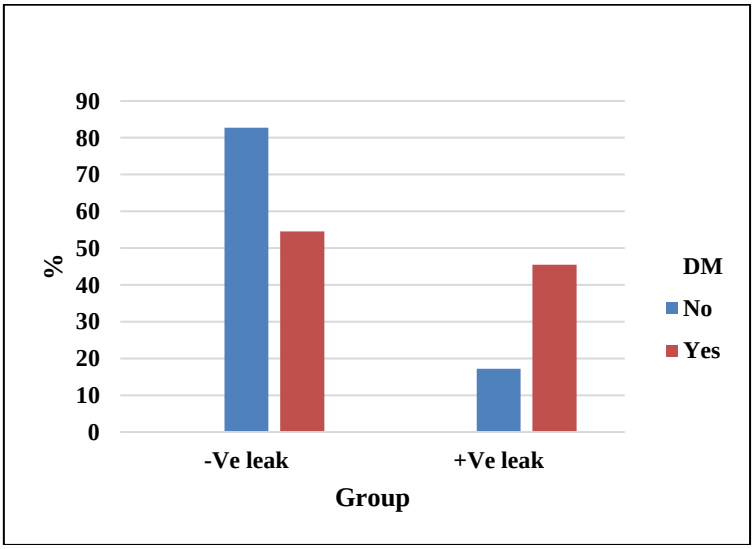

30.0
25.0
20.0
15.0
10.0
5.0
0.0
BMI
-Ve leak
+Ve leak

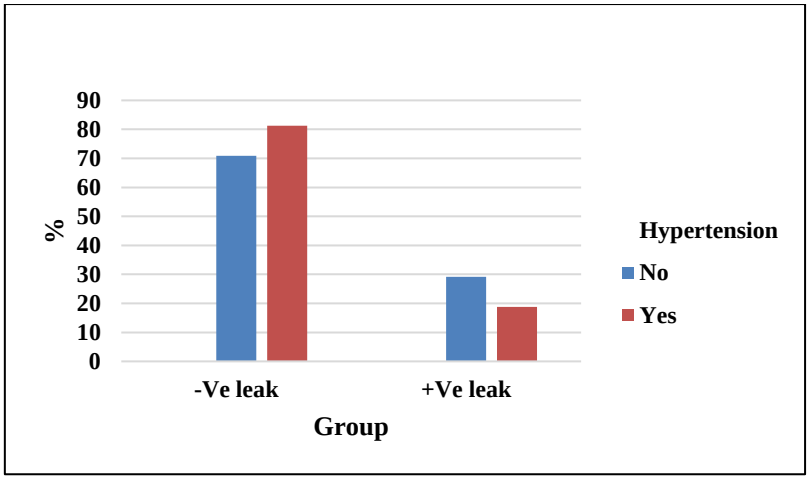

50
45
40
35
30
25
20
15
10
5
0
Age (years)
-Ve leak
+Ve leak

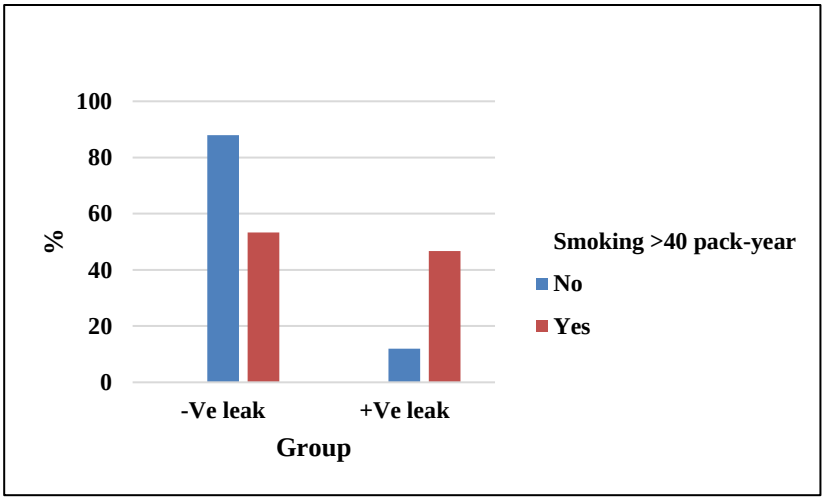

120
100
80
60
40
20
0
%
-Ve leak
+Ve leak
Group
BMI (≥25 kg/m2)
No
Yes

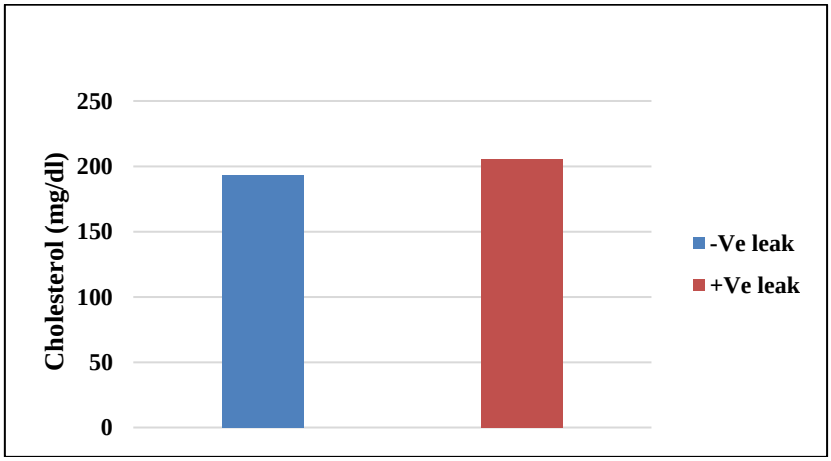

80
70
60
50
40
30
20
10
0
%
-Ve leak
+Ve leak
Group
Sex
Male
Female

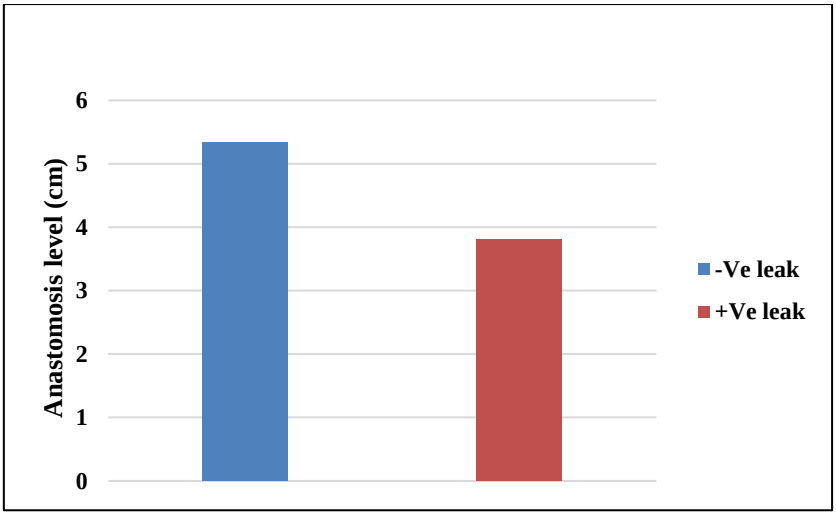

120
100
80
60
40
20
0
%
-Ve leak
+Ve leak
Group
ASA score
I
II
III


90
80
70
60
50
40
30
20
10
0
%
-Ve leak
+Ve leak
Group
DM
No
Yes


90
80
70
60
50
40
30
20
10
0
%
-Ve leak
+Ve leak
Group
Hypertension
No
Yes


100
80
60
40
20
0
%
-Ve leak
+Ve leak
Group
Smoking >40 pack-year
No
Yes


250
200
150
100
50
0
Cholesterol (mg/dl)
-Ve leak
+Ve leak



Discussion

Anastomotic consequences, particularly early postoperative anastomotic leaks, remain unpredictable and are sometimes fatal, despite the significant positive effects that better minimum access procedures and enhanced perioperative care regimens have had on short and intermediate postoperative outcomes. Anastomotic breakdown may result from mechanical issues or issues with the blood flow.[11] An innovative method to assess the anastomotic perfusion during laparoscopic colorectal surgery that permits the assessment of the vascular circulation of the intestine is ICG dye.[12] Our study aimed to assess anastomosis perfusion intraoperatively using ICG dye angiography in patients undergoing laparoscopic colorectal resection.

In our study, the mean age in the positive leak group was 46.20±13.07 and in the negative leak group was 46.77±12.93. There was no prominent variation between the two groups regarding age and sex.

Our result are supported with wada et al.,[13] who aimed to evaluate colonic perfusion in laparoscopic colorectal surgery using ICG fluorescence imaging. Their study included 112 patients with left-sided colon cancer. Laparoscopic sigmoidectomy ($n = 47$; 42%), laparoscopic high anterior resection (n = 13; 11.6%), and laparoscopic low anterior resection ($n = 52$; 46.4%) were performed. There was no significant difference between age and sex.

But according to Pommergaard et al.,[14] The male gender is a risk factor and increases the incidence of anastomotic leakage. In our study, changes in the transaction line occurred in 4 cases (10%), and anastomotic leakage occurred in 2 cases among the 4 cases (50%). But according to Wada et al.,[13] Based on the fluorescence imaging, the surgical team sought a more proximal change of the transection line in 18 cases (16.1%). Among the 18 patients, anastomotic leakage occurred in 4 patients (4/18: 22.2%).

In our study, there was a significant difference between the two groups regarding smoking. There was a prominent increase in the frequency of patients who smoke > 40 cigarettes per year in patients with positive leaks compared with patients with negative leaks.

But according to kawada et al.,[15] there was no prominent variation regarding smoking among the studied patients.

In our study there was no prominent difference between 2 groups according to preoperative chemotherapy.

Our results are supported with boni et al.**,** [16] who aimed to assess perfusion of the intestine during laparoscopic resection of the colon using ICG dye

Computing interests:
The authors declare that they have no computing interests
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